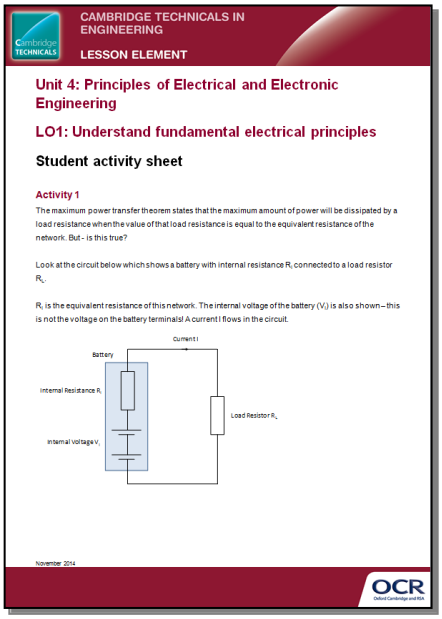
Unit 4: Principles of Electrical and Electronic Engineering

LO1: Understand fundamental electrical principles – Maximum power transfer

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Understanding fundamental electrical principles – Maximum power transfer' *activity which supports Cambridge Technicals in Engineering Level 3.*


CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 4: Principles of Electrical and Electronic Engineering

LO1: Understand fundamental electrical principles

Student activity sheet

Activity 1

The maximum power transfer theorem states that the maximum amount of power will be dissipated by a load resistance when the value of that load resistance is equal to the equivalent resistance of the network. But - is this true?

Look at the circuit below which shows a battery with internal resistance R_i connected to a load resistor R_L.

R_i is the equivalent resistance of this network. The internal voltage of the battery (V_i) is also shown – this is not the voltage on the battery terminals! A current I flows in the circuit.

November 2014

OCR

The Activity:

In this task the students are tasked with finding the internal resistance of a battery including plotting a graph to show load power for varying values of resistance.

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

Suggested timings:

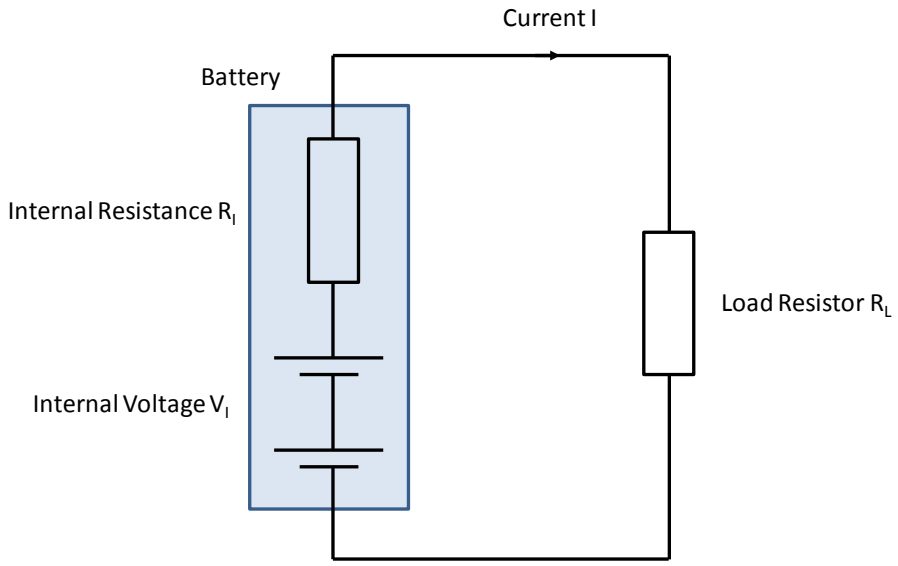
2 hours

December 2014

Activity 1

The maximum power transfer theorem states that the maximum amount of power will be dissipated by a load resistance when the value of that load resistance is equal to the equivalent resistance of the network.

Learners have been presented with a circuit showing a battery with internal resistance R_I connected to a load resistor R_L. The circuit is shown below:



The internal resistance of the battery is 200Ω and the internal battery voltage is 9v.

1. Maximum power will be transferred to the load when its value is equivalent to the internal resistance of the battery according to the Power Law. For maximum power transfer R_L should be 200Ω.

2. Learners have been tasked to plot a graph showing load power for varying values of load resistance from 50Ω to 400Ω (in steps of 10Ω).

Load Resistor Value R_L	Circuit Current I	Load Power P
50Ω	0.036A	0.0648W
60Ω	0.034615A	0.0719W
70Ω		
80Ω		

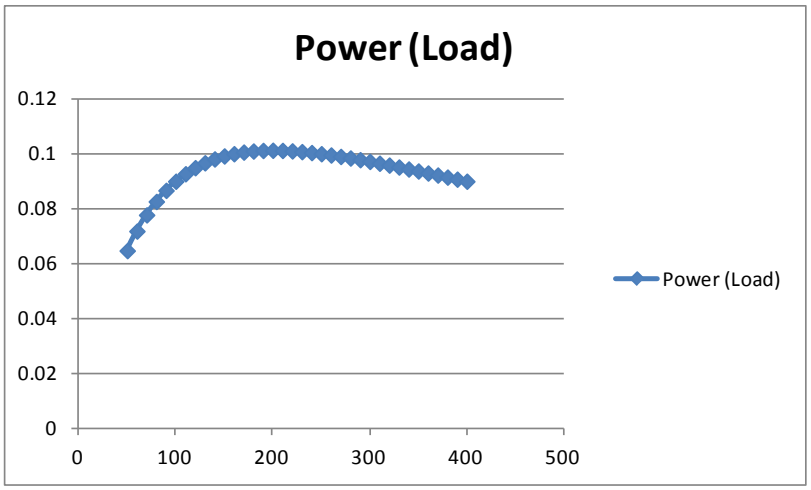
In order to calculate circuit current, learners will need to apply Ohms law using internal battery voltage and total circuit resistance ie:

$$I = \frac{Internal\ battery\ voltage\ V_I}{Internal\ Resistance\ R_I + Load\ Resistance\ R_L} \text{ (Amps)}$$

Power in the load resistance is calculated using the circuit current and value of load resistance ie:

$$P_{LOAD} = I^2 R_L \text{ (Watts)}$$

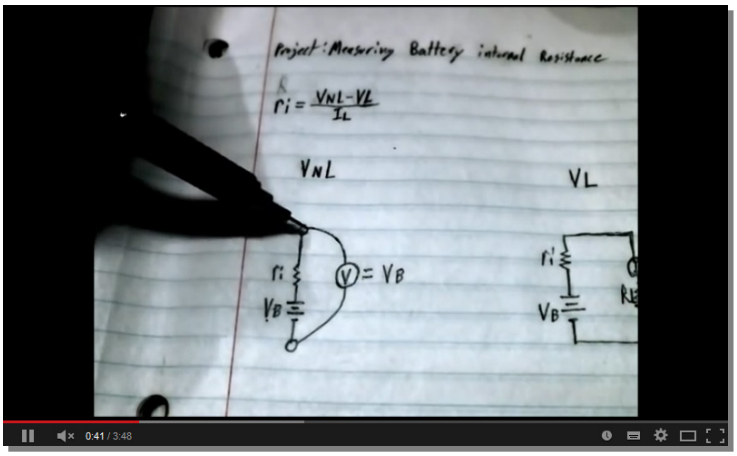
Learners might be able to use a spreadsheet (available with this Lesson Element) to plot a graph of load power (vertically) against load resistance (horizontally). The resulting graph is shown below:



The graph demonstrates that maximum power is transferred to the load resistor when it has the same value as the internal resistance of the battery. In this example maximum power transfer occurs when the value of the load resistor is 200Ω.

Activity 2

In the second activity learners are tasked to watch a video showing how to measure the internal resistance of a battery.



http://youtu.be/HZUDFcOSe48

Learners could undertake this activity as a practical experiment if access to suitable resources is available.

Equipment to undertake the experiment:

- 9V PP9 battery.
- Load Resistor (in the range 500Ω to 1000Ω, ¼ watt).
- Multimeter (with volts and amps ranges).

Learners could determine the internal resistance of the battery and write this as an experimental report (to include list of equipment used, method, results and conclusions). Learners should apply Ohms law (as shown in the video) to determine internal resistance.

Learners should conclude that connecting a resistor to the battery, with a value equivalent to the internal resistance of the battery, will result in maximum power being transferred.

The experiment could be extended, by investigating the effects of varying the load resistance on the battery, and a graph of load resistance vs load power being plotted from measured values. This is similar to Activity 1, except that learners are undertaking an experiment to determine maximum power transfer practically.

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